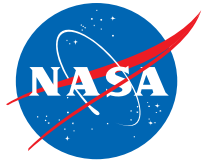


METABOLIC COST OF EXPERIMENTAL EXERCISES

James T. Webb[1], Ph.D. and Michael L. Gernhardt[2], Ph.D.

[1] Scientific Aerospace Research Consulting (SARC), LLC
San Antonio, TX

[2] EVA Physiology, Systems & Performance (EPSP)
NASA Johnson Space Center, Houston, Texas

INTRODUCTION

- 8 activities performed during 17 altitude decompression sickness (DCS) protocols at Brooks City-Base, TX from 1983-2005
- Determination of metabolic cost of activity during nearly all of those subject-exposures was not accomplished
  - Equipment, interest, and funding limitations
- Subject activities during each minute of exposure were documented and consistent
- Isometric leg, isometric arm, dynamic leg, and dynamic arm exercises were tested at an equivalent metabolic cost - No difference in DCS risk
  - Mode of activity not the major factor

BACKGROUND & METHODS

- Potential relationship between metabolic cost and DCS risk postulated late in the research
  - Approximation of metabolic cost vs. DCS incidence in 4 profiles
  - Same altitude, time at altitude, and prebreathe time (3 of 4 primary DCS risk factors)
  - Metabolic cost and DCS incidence appeared to be correlated
- Needed method for measuring metabolic cost
  - Ability to do the different activities consecutively w/o interruption
  - COSMED K4b^2 used by NASA for sub-maximal metabolic cost determinations
    - » Breath-by-breath; $\mathbf{V}O_2$; 30-sec averages
    - » Seated rest control before each sequence of activity

SUBJECTS

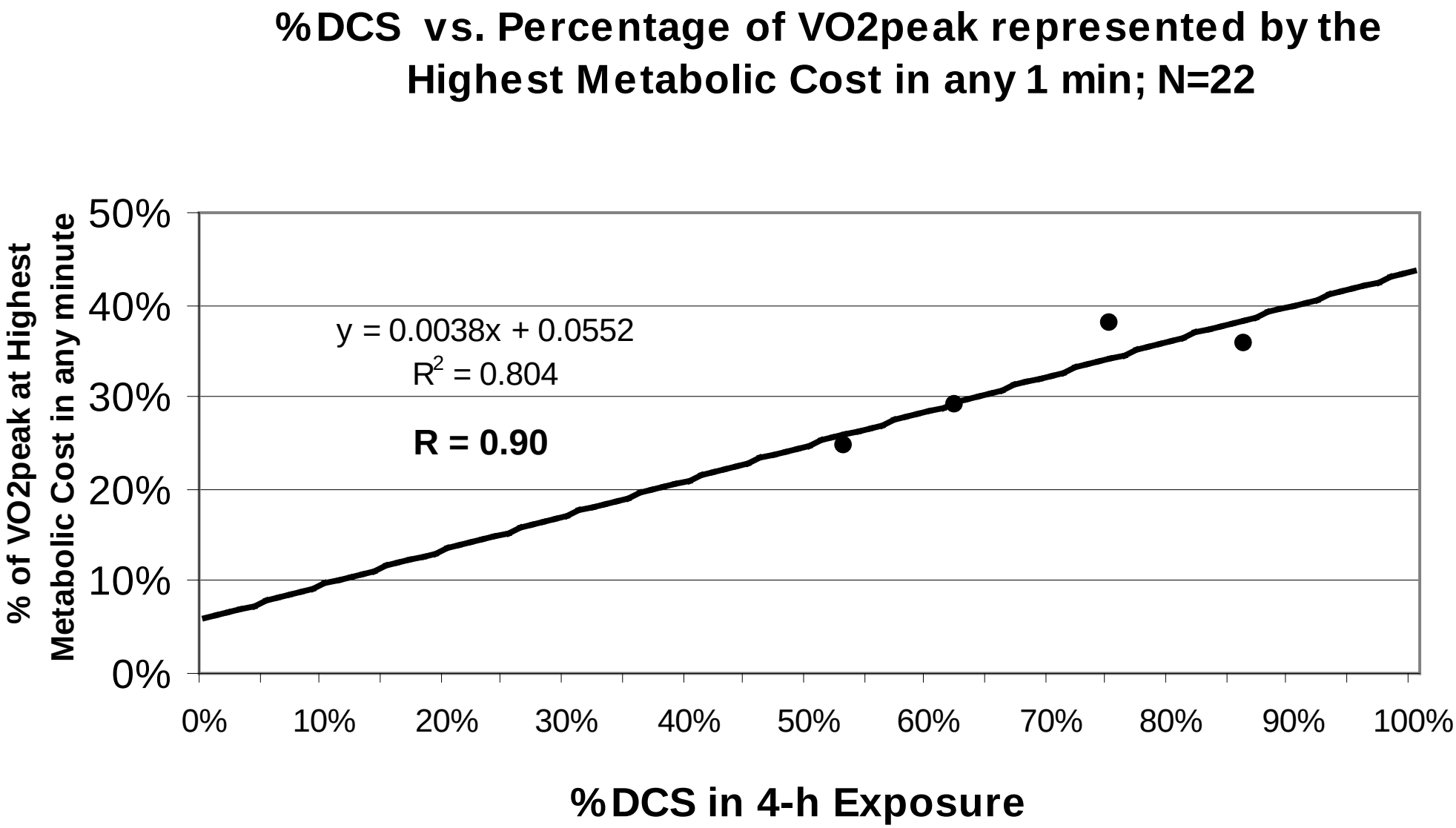
- 22 [of the 30 planned] subjects performed the identical exposure activities at ground level in the same chamber used for the earlier altitude exposures.
- The protocol and informed consent were approved by the NASA JSC Committee for the Protection of Human Subjects and the Wright Patterson AFB Institutional Review Board.

	Age,	Weight,		Height,			BF,	VO2max,	
	y	#	kg	in	m	BMI	%	l/min	ml/kg/min
Subject Mean	29.8	158.8	72.2	68.0	1.7	24.1	18.0	2.9	39.1
Database Mean	30.1	172.3	78.3	69.0	1.8	25.4	19.3	3.2	40.3

RESULTS

- Plotted vs. DCS during 4-h exposures to 30,000 ft following a 1-h prebreathe
- Parameters evaluated throughout each activity sequence
  - Mean $\dot{V}O_2$ (R<0.50)
  - Mean Increase in $\dot{V}O_2$ from seated rest control (R<0.43)
  - Mean % of $\dot{V}O_{2peak}$ (R<0.50)
- Parameters evaluated during the highest 1-min of each activity sequence
  - Mean $\dot{V}O_2$ and Mean kcal/h (R<0.87)
  - Mean Increase in $\dot{V}O_2$ from seated rest control (R<0.86)
  - Mean % of $\dot{V}O_{2peak}$ (R<0.90)

CORRELATIONS



DISCUSSION

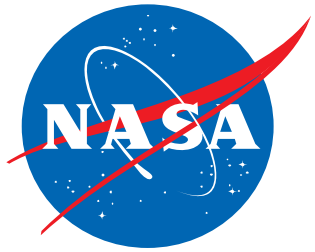
- The correlation between DCS incidence and the highest 1-min metabolic cost or as a percentage of $\dot{V}O_{2peak}$ being much better than that between DCS incidence and average metabolic cost or average percentage of $\dot{V}O_{2peak}$ was unexpected.
- Possible reasons
  - Bubble formation resulting from more active muscle metabolism while decompressed
  - Muscle shear forces being greater during short-term relatively heavy exertion
- Possible implications
  - Measurement of $\dot{V}O_2$ during a little as 1-min of an activity peak exertion may be a good DCS risk prediction tool based on % of $\dot{V}O_{2peak}$
  - Beware of even short-term, high physical stress activity while decompressed
  - Plan for higher activity after additional exposure time (denitrogenation time)

PLANS

- **The Brooks DCS Research database contains no exposures below 35,000 ft which required only seated rest and echo-imaging joint articulations.**
- **A prediction of significantly lower DCS risk for seated rest and echo-imaging joint articulations is implied by using data from the current research.**
- **Future research could include seated rest exposures and echo-imaging joint articulations at altitudes where analogous prebreathe and exposure durations could test the hypothesis that lower level (metabolic cost) activities would yield much less DCS risk.**
  - **22,500, 25,000 ft, and 30,000 ft**
- **Update of the USAF Altitude DCS Risk Assessment Computer model may also be possible using the current data.**
- **Inclusion of these finding could improve DCS prediction using a NASA model.**

CONCLUSIONS

- Correlation between average metabolic cost and DCS risk was poor
- There was a very good correlation between short-term higher level physical activity and DCS risk
  - Highest 1-min segment; Correlation = 0.90
- Prediction of DCS risk based on 1-min spikes in $\dot{V}O_2$ may be a useful tool in planning decompression activity scenarios



METABOLIC COST OF EXPERIMENTAL EXERCISES

James T. Webb, Ph.D. and Michael L. Gernhardt, Ph.D.